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ELECTRONICALLY FILED

January 16, 2003

Ms. Marlene H. Dortch, Secretary Federal Communications Commission 445 12th Street, SW Washington, DC 20554

Dear Ms. Dortch:

On our own behalf, Hammett & Edison, Inc., Consulting Engineers, hereby files *ex parte* comments to MM Docket 00-39, in support of the November 8, 2002, *Petition for Partial Reconsideration* of the Commission's August 9, 2002, *Second Report & Order and Second Memorandum Opinion & Order* to MM Docket 00-39.

Sincerely yours,

Dane E. Ericksen

kf

Enclosure

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Hammett & Edison, Inc. Comments in Support of the Sinclair Petition for Partial Reconsideration for DTV Receiver Standards

January 16, 2003

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Comments of Hammett & Edison, Inc., Consulting Engineers

The firm of Hammett & Edison, Inc., Consulting Engineers, hereby submits its comments in support of the November 8, 2002, Sinclair Broadcast Group, Inc. ("Sinclair") Petition for Partial Reconsideration of the Commission's August 9, 2002, Second Report & Order and Second Memorandum Opinion & Order to MM Docket 00-39, which adopted a requirement that television receivers sold in or imported into the United States have the capability to receive over-the-air DTV transmissions commencing in 2004. Hammett & Edison, Inc. ("H&E") fully agrees with the premise in the Sinclair petition, namely, that it is not sufficient merely to adopt a DTV tuner requirement; rather, certain minimum performance requirements for the DTV tuner must be adopted, as well.

Background

Hammett & Edison has for over 50 years provided consulting engineering services to TV broadcast stations throughout the U.S. Our firm has been actively involved in the planning and implementation of the new DTV service in the U.S. and is well qualified to submit comments in the instant matter. These comments are intended to provide, for the Commission's review, additional documentation of the problems that are identified in the Sinclair Petition, based on recent measurements of TV service conducted by our firm. The several cases included here are believed to be indicative of other, similar problems observed elsewhere in the U.S. as the mandated DTV services commence in earnest.

Basis for Support of the Sinclair Petition

In January 2002, H&E was retained by a network affiliate to conduct measurements on certain NTSC and DTV signals in the San Francisco area. One of the stations measured was KNTV-DT, DTV Channel 12, San Jose, California. At some of the measurement points, adequate DTV signal strength was observed, but the consumer grade DTV receiver, an RCA Model DTC-100, would not achieve signal lock. It was subsequently determined that this was due to the inability of the RCA DTV receiver to reject the fundamental frequencies of several nearby San Francisco area FM broadcast stations. Revisiting two points where adequate DTV signal strength was observed but no receiver lock could be obtained, and then inserting a K&L Model 5BT-125/250-5B tunable band pass filter, confirmed that the problem was one of receiver overload by the FM station fundamental signals, rather than inadequately suppressed second harmonic energy from the FM stations. Insertion of the band pass filter allowed the RCA DTV receiver to achieve signal lock and display virtually perfect picture and audio quality from KNTV-DT, more than 80 kilometers distant. Documentation regarding these measurements is provided in the attached Figures 1 through 5.

Imperative Need for Minimum DTV Receiver Performance Criteria

Sinclair argues that adopting only a DTV tuner requirement will not be enough to ensure a successful transition to DTV in the United States; Sinclair further argues that the DTV tuner must have a reasonable ability to reject strong out-of-band and out-of-channel undesired signals if DTV is to succeed. We agree. We believe that marketplace forces would be slow in forcing production of DTV tuners with the ability to survive in spectrum-congested environments such as those typical of major television markets. This is because consumers have become accustomed to having TV receivers work in all but the most extreme RF environments, and even then the "fail gracefully" nature of NTSC generally allows useable, albeit degraded, reception. Not so for DTV: If receiver lock is not achieved, the consumer sees just blue screen squelch and has no clue as to the nature of the problem.

What makes DTV so different from NTSC is the substantially lower power levels of DTV stations, and the much lower signal levels that DTV receivers are expected to cope with. For example, for VHF low band TV signals the analog threshold is the F(50,50) 47 dBu Grade B signal strength, whereas the corresponding DTV threshold is the F(50,90) 28 dBu signal strength (equivalent to the F(50,50) 34.1 dBu)¹—almost 13 dB weaker. For VHF high band, the analog vs. digital thresholds are the F(50,50) 56 dBu and the F(50,90) 36 dBu (equivalent to the F(50,50) 42.1 dBu), a 14 dB difference, and at UHF the analog vs. digital thresholds are the F(50,50) 64 dBu and the F(50,90) 41 dBu (equivalent to the F(50,50) 48.1 dBu), a 16 dB difference. In contrast, undesired signals from FM stations, NTSC TV stations, other services, and man-made noise have not taken a 13 to 16 dB reduction in their power levels. In short, DTV receivers must contend with a much less favorable RF environment than analog (NTSC) receivers have traditionally had to.

Most consumers considering the purchase of a DTV receiver will undoubtedly not appreciate this difference. Rather, they will simply assume that "of course" the FCC has ensured that consumer grade DTV tuners are capable of operating properly in the majority of cases. Yet, based on the Commission's decision NOT to adopt any minimum DTV receiver performance requirements, that assumption would be risky, indeed. Thus, we believe that there is a fundamental difference between NTSC tuner performance and DTV tuner performance insofar as the intentionally minimal "adequately receiving" language of the 1962 All Channel Receiver Act ("ACRA"). That is, given the all-or-nothing nature of DTV reception, meeting the ACRA requirement of "adequately receiving" requires a higher standard than was sufficient for analog receivers.

Finally, we wish to make it clear that we are only urging the Commission to reconsider its decision not to adopt DTV receiver technical standards in regards to the DTV receiver's *RF performance* (i.e.,

¹ See Appendix 2, Section 3, page 63 of the U. S.-Canada DTV Letter of Understanding (LOU).



reasonable brute force overload and image immunities, discussed in greater detail below), and to leave to the consumer marketplace issues of post-demodulation signal processing. Post-demodulation signal processing will determine the level of the audio and video quality ultimately delivered to the display portion of the receiver, and those are areas where the consumer is capable of making his or her own judgments.² But first the "front end" of the DTV tuner must be robust enough to ensure that the DTV signal can make it from the RF domain to the demodulated digital signal domain.

Brute Force Overload Immunity

The Commission should adopt DTV tuner standards that will ensure reasonable immunity of DTV tuners against brute force overload ("BFO"). This includes not only reasonable immunity from strong FM signals, but also reasonable immunity from intermodulation products created by the mixing of multiple other TV signals in the DTV tuner front-end. This is especially important given the higher station density that now exists in the TV bands (and getting worse, as more DTV stations actually commence operation). Although this spectrum density will decrease after the transition period, that decrease will be partly offset by the need to find in-core channels for the present universe of out-of-core DTV stations.

Further, since the Commission has decided to protect DTV allotments only against co-channel and first-adjacent channel interference, then especially during the transition period the burden to protect against receiver front-end intermodulation problems will fall entirely on the DTV tuner. If the Commission wants to guide the way to a smooth transition to DTV, it needs to establish, at least in these early years, certain minimum BFO immunity requirements. The much more rigorous burdens on DTV receivers imposed by the fundamental change in the allocations scheme was recognized and characterized in a white paper written by Mr. John Norsworthy, founder and Chief Technical Officer for Microtune, Inc., *Technical Backgrounder: Solving the Technical Challenges of DTV*.³ Since there is no evidence in the Electronic Comment Filing System ("ECFS") that either Mr. Norsworthy or Microtune, Inc. filed comments to the MM Docket 00-39 rulemaking, we have obtained permission from Microtune to attach a copy of Mr. Norsworthy's paper to these comments. It is exceptionally well written, authoritative, and documented. Except for the instant Sinclair petition, it is the only literature we have found that appears to recognize the DTV receiver problem and how critical significantly better performing DTV tuners will be to the success of over-the-air terrestrial digital television.

³ See www.microtune.com/news/WP DTV 12.99.PDF.



We realize that the amount of post-demodulation receiver equalization can also impact the ability of a DTV receiver to achieve signal lock. Nevertheless, we believe that this aspect of DTV receiver performance is best left to the consumer marketplace.

Image Interference

The Commission's decision only to protect DTV allotments against co-channel and first-adjacent channel interference also creates a potential for the image interference from stations separated by 15 channels. Accordingly, in addition to reasonable levels of BFO immunity, DTV receivers must have image interference immunity. We believe that means a requirement for receivers with a double-conversion intermediate frequency ("I.F.") stage, and we urge the Commission to consider such a requirement. Failure to do so will virtually guarantee image interference problems in major TV markets, and probably in medium TV markets, as well.

Indeed, just such a case has recently come to our attention: Station KTVU-DT, DTV Channel 56, Oakland, California, transmitting from Sutro Tower in San Francisco, reports a DTV viewer complaint of interference from Station KKPX-DT, DTV Channel 41, San Jose, California, which transmits from San Bruno Mountain, about 8 kilometers south of Sutro Tower. The viewer reports that when KKPX-DT comes on the air (KKPX-DT is presently operating just from 8 PM to 11 PM, seven days a week), reception of KTVU-DT is lost entirely.⁴ Maps showing the locations of KTVU-DT, KKPX-DT and the location of the complaining viewer are provided in the attached Figures 6A and 6B. Although in this case the KTVU-DT problem is aggravated by the fact that the complaining viewer has line-of-sight to the KKPX-DT transmitting antenna atop San Bruno Mountain but lacks line of sight to the KTVU-DT transmitting antenna on Sutro Tower, as shown by the attached Figures 6C and 6D, this is hardly likely to be a unique, or even an unusual, situation). Indeed, as shown by the double shadowgraph map, Figure 6E, there are substantial portions of the heavily populated San Francisco peninsula where potential DTV viewers will have line of sight to KKPX-DT but lack line of sight to KTVU-DT.

We note that KKPX-DT is 15 channels below KTVU-DT; if consumer grade DTV receivers are using a conventional single-conversion 45 MHz I.F., then KKPX-DT could generate an image frequency for a receiver with a "low side" local oscillator⁵ attempting to tune KTVU-DT. Alternatively, image interference could be caused even for a double conversion DTV receiver if the image rejection is limited; for example, a DTV receiver designed primarily to receive cable television or downconverted DBS feeds might have sufficient image rejection to deal with an array of multiple TV signals of approximately equal amplitudes, but it might not be able to deal with a case where an undesired DTV

We realize that most television receivers use "high-side" local oscillators. The receiver in question, a Hughes Model E86, tunes both the down converted direct broadcast satellite ("DBS") spectrum as well as terrestrial TV Channels 2–69. We are attempting to ascertain from the manufacturer whether the Model E86 receiver is single or double conversion, and whether it uses a low-side local oscillator, a high-side local oscillator, or both.



⁴ The viewer also reports that he loses his ability to receive KRON-DT, DTV Channel 57, and has gets degraded reception for KGO-DT, DTV Channel 24, when KKPX-DT commences operation. KRON-DT and KGO-DT also transmit from the Sutro Tower, and would have similar shadowing problems as shown for KTVU-DT, because all of the Sutro Tower DTV stations transmit from a single stacked antenna array.

station has line of sight and a desired DTV station does not (although obviously the terrain obstruction suffered by the KTVU-DT signal in the viewer's area is not too severe, or else the complainant would not be able to receive a good quality KTUV-DT signal during those periods when KKPX-DT is not transmitting). A viewer attempting to receive a distant DTV signal when close to an "undesired" DTV transmitter could suffer a similar, unfavorable desired-to-undesired signal ratio.

More complaints of image interference can be expected if a DTV receiver image rejection standard is not adopted, as more and more households purchase DTV receivers that either are single conversion or are double conversion but without the ability to withstand large dynamic ranges between "desired" and "undesired" signals.

We believe that non-technical, "early adopter" viewers would be upset to learn that the reception problem is in their consumer grade DTV receiver, and not due to any underpower, overpower, or otherwise improper operation by KTVU-DT or by KKPX-DT. We believe that such viewers would feel "betrayed" and incredulous to learn that the FCC had adopted a system of DTV allotments that does not protect against image interference, AND also failed to adopt regulations to ensure that DTV receivers are immune to image interference. In other words, having decided not to adopt "DTV image interference" taboos for the Table of DTV Allotments, the Commission now needs to adopt a requirement that will make consumer grade DTV receivers immune to image interference: namely, require DTV receivers to use a double-conversion I.F. system.

Cost Concerns

We recognize that the Consumer Electronics Association ("CEA") opposes a requirement that TV receivers have a DTV reception capability beginning in 2004 for large screen receivers, and undoubtedly CEA would also oppose any minimum RF performance standards for such receivers. However, since minimum performance standards for DTV receivers would apply to all receiver manufacturers, no individual manufacturer would be disadvantaged. Further, significant strides in the performance and cost effectiveness of small size, high-performance, dual conversion TV tuners have been made in the last few years. The Microtune, Inc. MT2032 series and 404x series RF tuner modules are excellent examples of modern-day, high-performance tuner designs.⁶ We fear that, if the Commission requires just 8VSB tuners in television receivers, and not also minimum RF performance standards for such tuners, soon there will be a widespread universe of 8VSB tuners that can handle only the approximately equal amplitude carriers typical of cable TV or downconverted DBS feeds, and not the more challenging desired-to-undesired signal ratios common for direct over-the-air reception of terrestrial DTV signals. This would likely ensure the failure of DTV receivers with minimum-

⁶ See http://www.microtune.com/products/tvm.html.



performing 8VSB tuners to provide adequate reception in many of these situations. We cannot think of a worse "poison pill" for the rollout of DTV penetration than to encourage the marketing of TV receivers with DTV tuners that work only in benign RF environments.

Summary

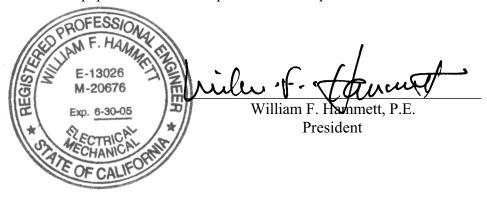
Sinclair is entirely correct: The Commission must reconsider its decision not to adopt minimum standards for DTV receivers. Protection is needed against both BFO and receiver image problems. The normal marketplace force represented by an informed consumer is impaired in the case of newcomer DTV receivers. First, the UHF NTSC analog taboos for many years have lulled consumers away from having to concern themselves with receiver BFO and image interference issues, because the UHF taboos protected against this; that protection does not exist for DTV allotments. Second, the ungraceful way that DTV receivers handle loss of signal lock due to BFO or image interference, by a step change to a blue squelch screen, limits the consumer's ability to understand the nature of the problem.

For these reasons, Hammett & Edison believes that the Commission erred in its interpretation of the "receiving adequately" provision of the ACRA and should reconsider its decision not to adopt minimum performance standards for DTV tuners. We believe the Commission should issue an Order on Reconsideration reversing its decision not to require minimum performance standards for DTV receivers, along with a Further Notice of Proposed Rulemaking intended to establish such minimum standards.

List of Figures

The following attached figures are submitted in support of these comments in support of the Sinclair petition:

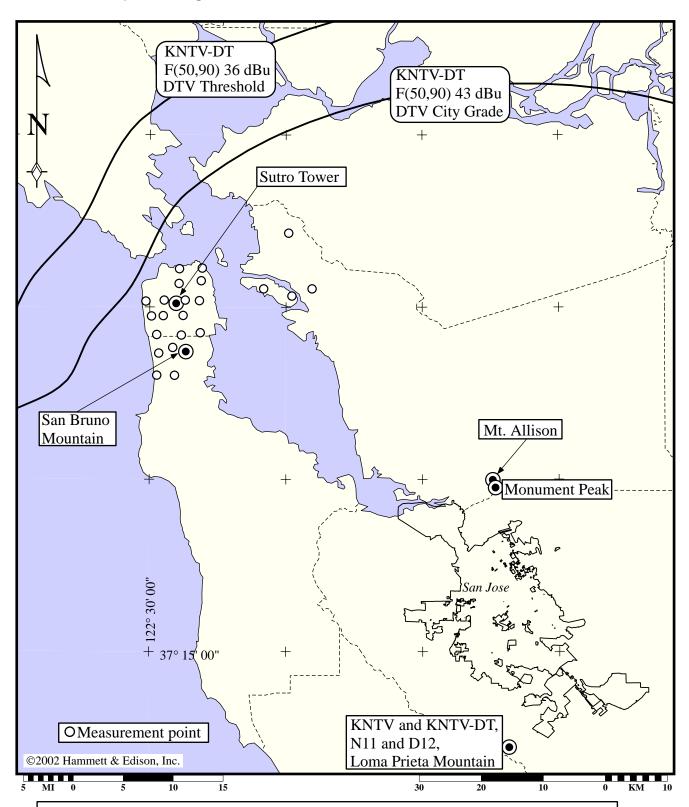
- 1. Maps showing measurement points
- 2. Equipment configuration and photographs
- 3. Point 12 measurements
- 4. Point 15 measurements
- 5. Band pass filter photograph and spectrographs
- 6. KTVU-DT vs. KKPX-DT image interference figures
- 7. Copy of Microtune white paper on DTV tuner performance requirements.





January 16, 2003

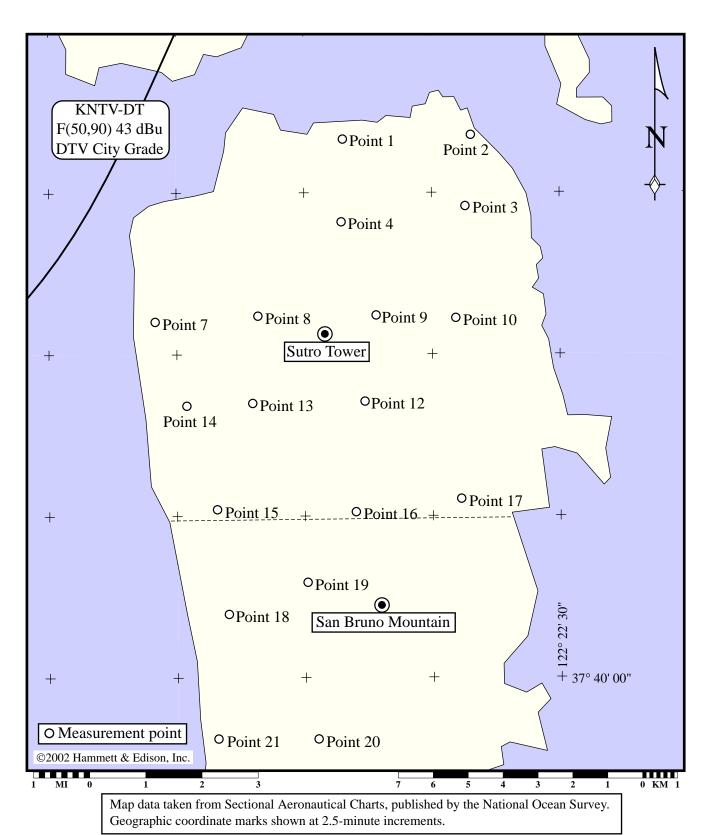
Map Showing Measurement Locations and Measured TV Stations



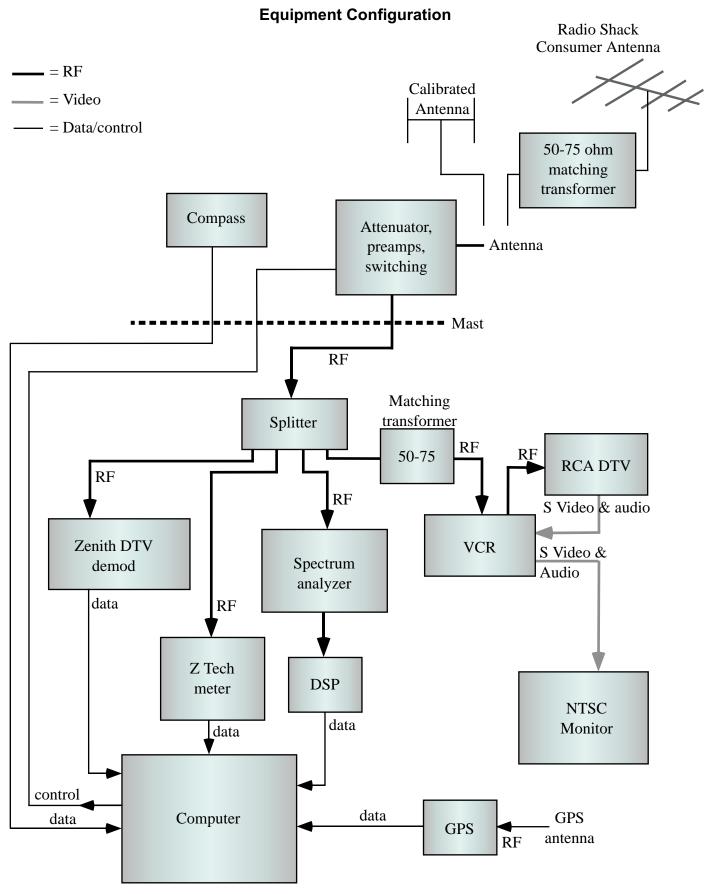
Map data taken from Sectional Aeronautical Charts, published by the National Ocean Survey. Geographic coordinate marks shown at 15-minute increments. City limits shown taken from U.S. Census Bureau TIGER/Line 2000 data.



San Francisco/Northern San Mateo County Measurement Points







Measurement Van and Equipment



Van photo showing the measuring equipment.

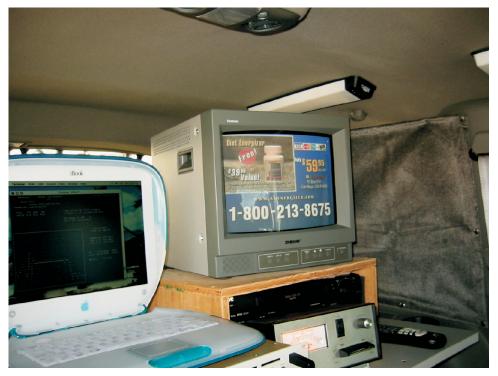


Photograph of the pneumatic mast with Bi-Log antenna mounted. The rectangular box next to the antenna rotor contains computer-controlled amplifiers, attenuators, and coaxial relays. An electronic compass is housed in a circular box just behind the antenna rotor.

Measurement Van and Equipment



Close-up photo of the Z-Technology field strength meter and the Tektronix spectrum analyzer.



Close-up photo of the Sony television monitor used for the preliminary picture quality ratings in the field, using the TASO scale. The final TASO values were obtained by viewing the recorded signals in a darkened room using a 19-inch monitor.

MM Docket 00-39 • DTV Review Rulemaking Point 12 Photos

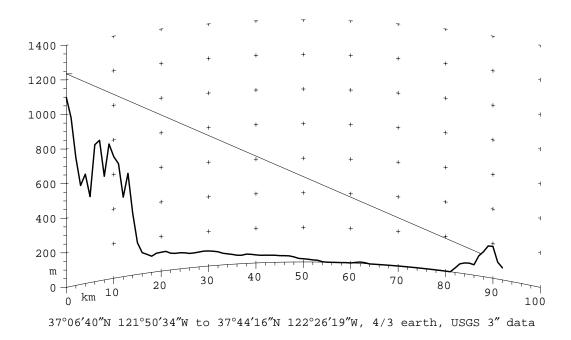


Point 12, Arbor Street at Diamond Heights Boulevard, San Francisco. View is to the south.



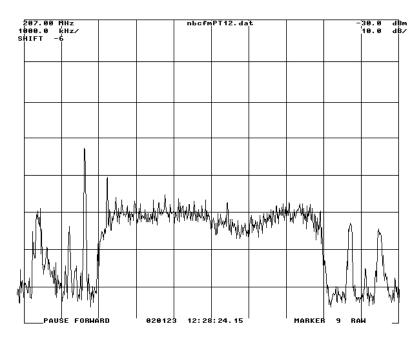
Point 12, Arbor Street at Diamond Heights Boulevard, San Francisco. View is to the northwest.

KNTV-DT Terrain Profile

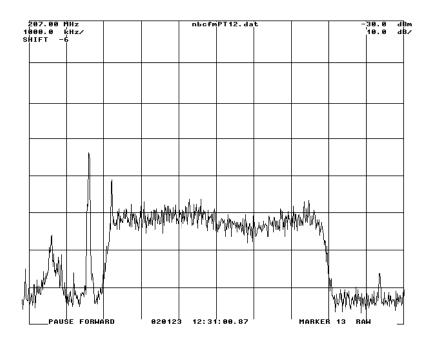


Terrain profile from KNTV-DT, D12, Loma Prieta Mountain, to Point 12, Arbor Street at Diamond Heights Boulevard, San Francisco. Profile extends 5 kilometers beyond measurement point.

Point 12 Spectrum Analyzer Plots



January 23, 2002, Point 12 re-visit, showing spectrograph of KNTV-DT, Channel 12 (204-210 MHz) spectrum WITHOUT bandpass filter. R-S antenna, aimed at Loma Prieta Mountain. Note the BFO "spurious" signals on either side of KNTV-DT, and also in the KNTV-DT channel (although obscured by the DTV signal). No lock was possible on the RCA DTV receiver.



January 23, 2002, Point 12 re-visit, showing spectrograph of KNTV-DT, Channel 12 (204-210 MHz) spectrum WITH bandpass filter. R-S antenna, aimed at Loma Prieta Mountain. The BFO "spurious" signals have all but disappeared, and the RCA DTV receiver was able to achieve signal lock.



MM Docket 00-39 • DTV Review Rulemaking Point 15 Photos



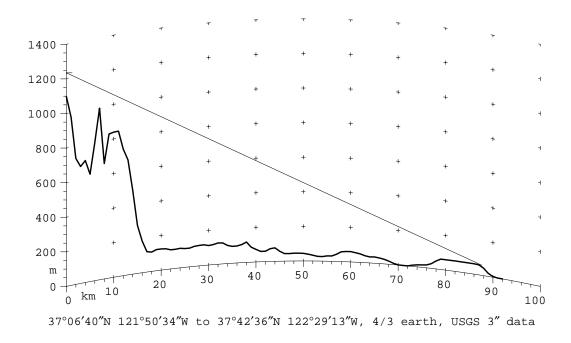
Point 15, on John Muir Drive, San Francisco. View is to the north.



Point 15, on John Muir Drive, San Francisco. View is to the south.

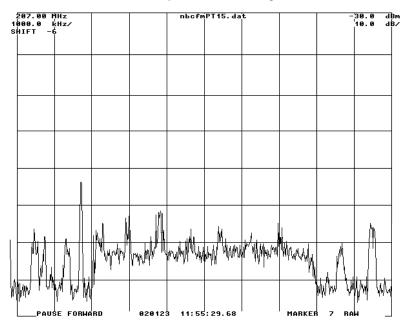


KNTV-DT Terrain Profile

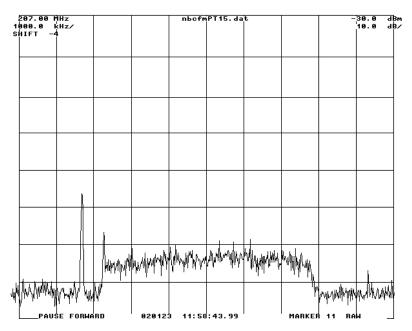


Terrain profile from KNTV-DT. D12, Loma Prieta Mountain, to Point 15, John Muir Drive, San Francisco. Profile extends 5 kilometers beyond measurement point.

Point 15 Spectrum Analyzer Plots



January 23, 2002, Point 15 re-visit, showing spectrograph of KNTV-DT, Channel 12 (204-210 MHz) spectrum WITHOUT bandpass filter. R-S antenna, aimed at Loma Prieta Mountain. Note the BFO "spurious" signals on either side of KNTV-DT, and also in the KNTV-DT channel (although obscured by the DTV signal). No lock was possible on the RCA DTV receiver.



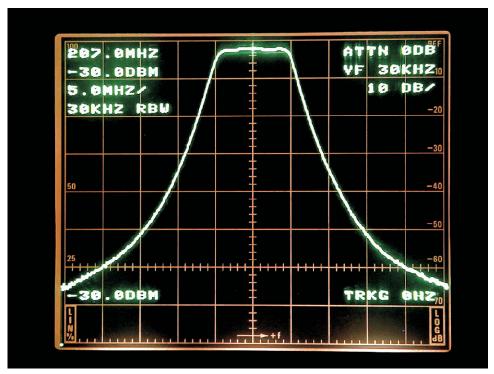
January 23, 2002, Point 15 re-visit, showing spectrograph of KNTV-DT, Channel 12 (204-210 MHz) spectrum WITH bandpass filter. R-S antenna, aimed at Loma Prieta Mountain. The BFO "spurious" signals have all but disappeared, and the RCA DTV receiver was able to achieve signal lock.

K&L Band Pass Filter

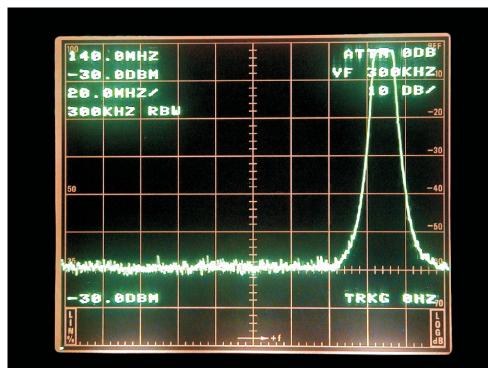


Photograph of the K&L Model 5BT-125/250-5B tunable band pass filter used to allow measurement of San Bruno Mountain and Sutro Tower FM broadcast station second harmonics, and test for BFO from TV Station KQED, NTSC Channel 9.

K&L Band Pass Filter Response



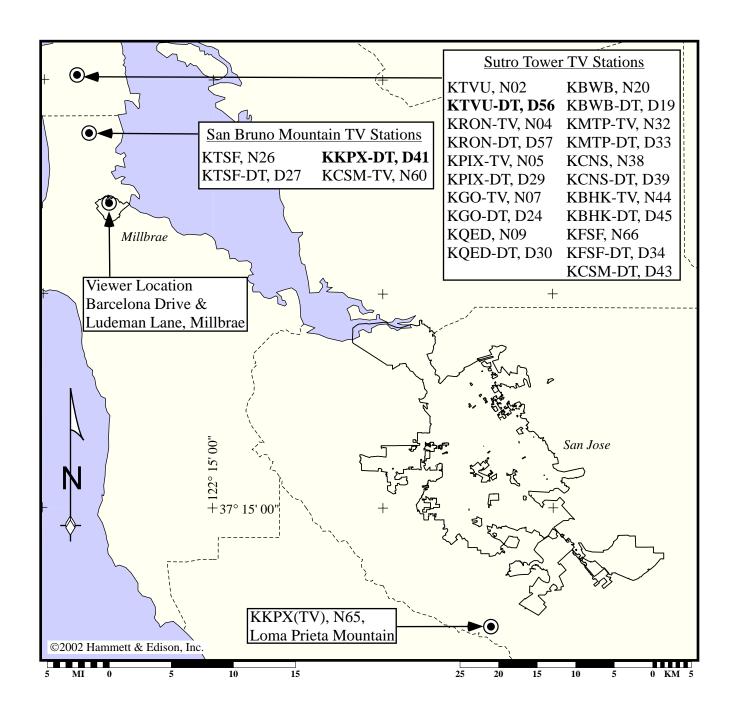
Bandpass characteristic: the -1 dB bandwidth is 8.5 MHz, and the -3 dB half-power bandwidth is 10 MHz, meaning that when tuned to Channel 11 or to Channel 12, the filter should have no impact on the desired signal except for an insertion loss of 1.1 dB.



Out-of-band rejection (including Channel 9) is at least 58 dB. This allows increasing the spectrum analyzer gain at the FM second harmonic frequencies without causing front-end spectrum analyzer overload.

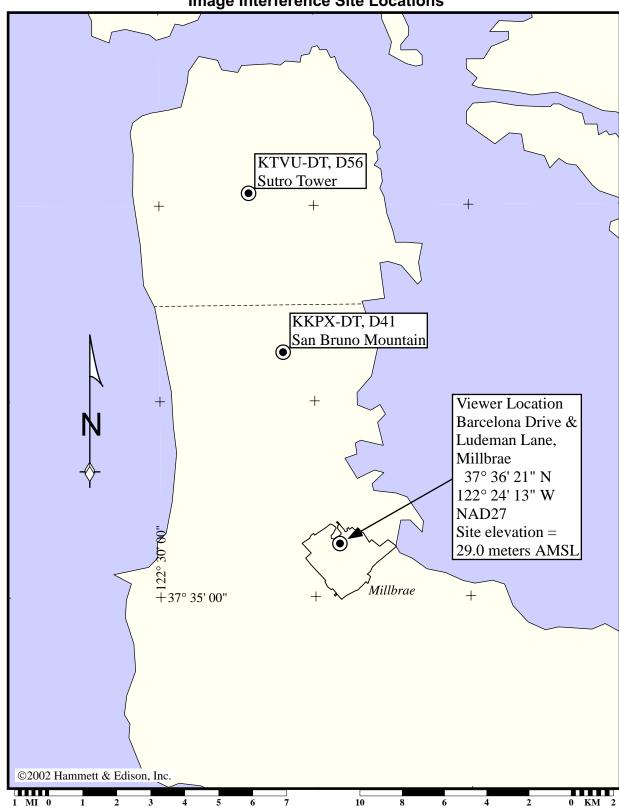


KTVU-DT, D56, vs. KKPX-DT, D41 Image Interference Site Locations



Lambert conformal conic map projection at. Map data taken from Sectional Aeronautical Charts, published by the National Ocean Survey. City locations and county lines shown taken from 2000 U.S. Census Bureau TIGER data. Geographic coordinate marks shown at 15-minute increments.

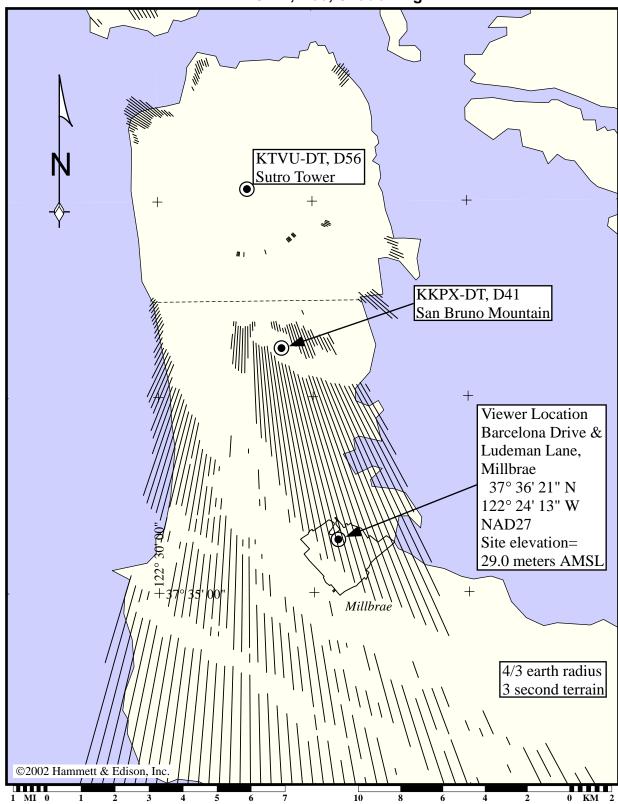
KTVU-DT, D56, vs. KKPX-DT, D41 Image Interference Site Locations



Transverse Mercator map projection. Map data taken from Sectional Aeronautical Charts, published by the National Ocean Survey. City locations and county lines shown taken from 2000 U.S. Census Bureau TIGER data. Geographic coordinate marks shown at 5-minute increments.

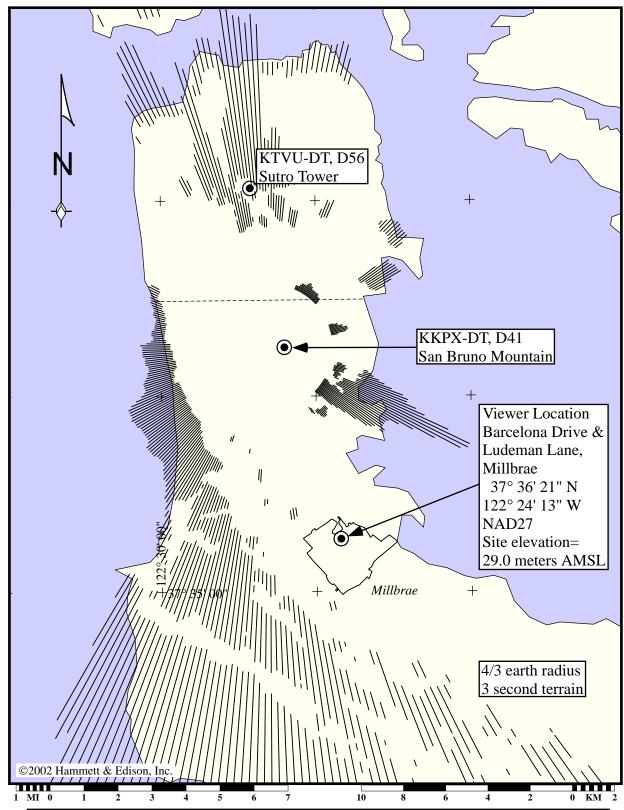


KTVU-DT, D56, Shadowing



Transverse Mercator map projection. Map data taken from Sectional Aeronautical Charts, published by the National Ocean Survey. City locations and county lines shown taken from 2000 U.S. Census Bureau TIGER data. Geographic coordinate marks shown at 5-minute increments.

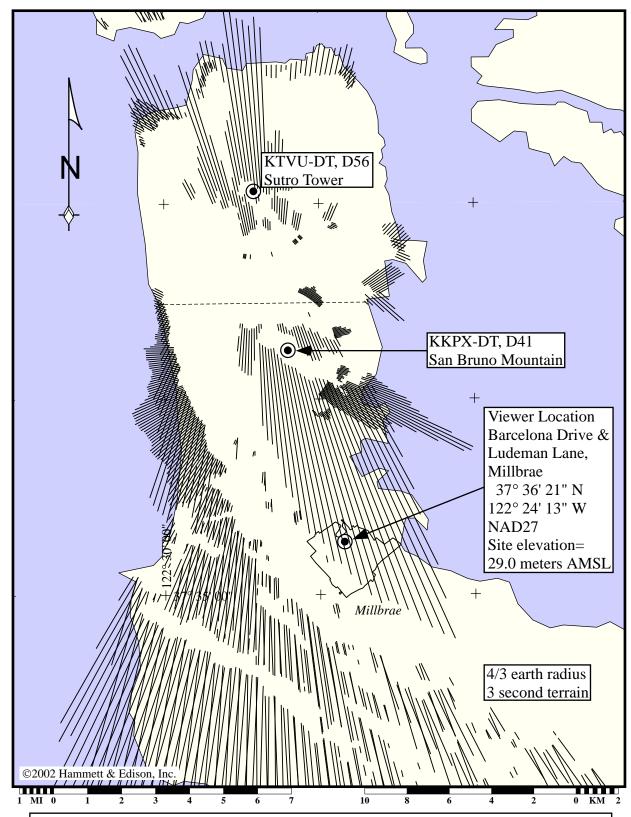
KKPX-DT, D41, Shadowing



Transverse Mercator map projection at. Map data taken from Sectional Aeronautical Charts, published by the National Ocean Survey. City locations and county lines shown taken from 2000 U.S. Census Bureau TIGER data. Geographic coordinate marks shown at 5-minute increments.



KTVU-DT and KKPX-DT Shadowing



Lambert conformal conic map projection at. Map data taken from Sectional Aeronautical Charts, published by the National Ocean Survey. City locations and county lines shown taken from 2000 U.S. Census Bureau TIGER data. Geographic coordinate marks shown at 5-minute increments.



M I C R O T U N E ™

TECHNICAL BACKGROUNDER: SOLVING THE TECHNICAL CHALLENGES OF DTV

By John Norsworthy, Founder and Chief Technical Officer, Microtune, Inc.



SOLVING THE TWO TECHNICAL CHALLENGES OF DTV BY JOHN NORSWORTHY, FOUNDER AND CHIEF TECHNICAL OFFICER

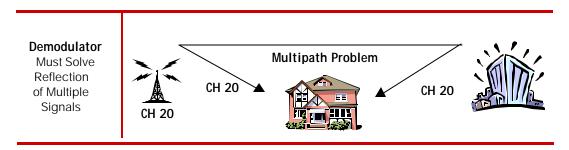
OVERVIEW

Recently, there has been a great deal of industry comment about the adequacy of 8-VSB as a means to distribute digital television. There are clear reasons why the FCC has adopted 8-VSB, rather than its European counterpart, COFDM, as the modulation scheme in the United States. To provide some clarity to the discussion, I will review both modulation schemes and compare their merits/ disadvantages relative to their end results. I will then offer an opinion on which scheme will ultimately succeed in the U.S. marketplace and why, as well as address an often-overlooked aspect of digital television reception: the tuner.

TECHNICAL OBSTACLE TO DTV: THE MULTIPATH PROBLEM

The issue identified by the Sinclair Broadcast Group in its 'real world' ATSC test case is the 'old' multipath problem. Multipath is the problem caused by a transmitted signal arriving at a receiver through multiple paths. These paths are reflections off buildings, airplanes, people moving around a room, etc. In analog video, multipath manifests itself as ghosts in the image, shadows of objects shifted across the screen. In really bad cases, the video breaks up. In digital video, which is either perfect or 'off', severe multipath interference can lead to loss of reception.

THE DEMODULATOR MUST SOLVE THE MULTIPATH PROBLEM



When a roof antenna is used, there is typically a line-of-sight path between the antenna and the transmitter. Furthermore, the roof antenna typically has directionality; it tends to receive signals from the direction in which it is pointed and rejects others. If the TV viewer is using a roof antenna, multipath is generally not a problem.

Unfortunately, the problems caused by indoor reception are not so easily addressed. The TV viewer may use a simple 'rabbit ears' antenna, or some other small, visually-attractive antenna that has virtually no directionality. In indoor applications, no directionality is required—it is impossible to know from where the signal is coming.

In a typical path in an urban setting, the signal will reflect off some buildings and enter the home through a window. The primary path may then reflect off walls and the like before arriving at the antenna. This is obviously a big multipath problem.

WHY DIGITAL TV?

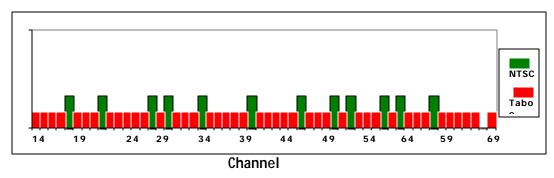
Before addressing the solutions to these problems, I think it important to step back and review why the U.S. (and the world) is headed down the digital path in the first place. There are two main thrusts behind digital television. The first, and most important one, is more efficient use of the spectrum. The second is providing consumers with a better television experience. 'Television experience' can be expanded to include other classes of broadcast digital services, such as data broadcasting, ondemand programming and interactive television.

Spectrum is valuable. Until now, the television industry has enjoyed a prime, disproportionately large segment of our nation's spectrum. More than half of this spectrum, ranging from 54 to 806 MHz, is left unused in any given locale. The decision-makers in Washington realize that a significant portion of the spectrum dedicated to broadcast television is currently unused.

THE INTERFERENCE PROBLEM

Would it surprise you to know that a primary reason for the inefficient use of spectrum is television tuner performance? In fact, the FCC, in granting licenses to broadcasters, specifically avoids, by mandate, the use of more than half of the available channels in a region. These channels, called *taboo channels*, consist of channels adjacent to an existing broadcaster and those at the so-called 'image channel' of an existing broadcaster. Channels that are harmonically related are also considered taboo. These taboo channels can potentially cause interference, manifested as lines or patterned noise on an analog TV set with a conventional television tuner. In digital TV, they can cause loss of reception. A diagram presenting the current analog television spectrum of Los Angeles is depicted below. It illustrates how much of the spectrum is 'protected' because of the taboo channels, a condition that is mirrored in major markets throughout the U.S.

BEFORE DTV: UHF NTSC SPECTRUM FOR LOS ANGELES

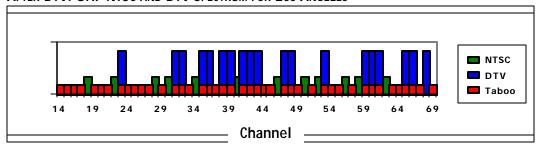


In the UHF band, nearly three quarters of the spectrum is unused. Almost every channel has an image channel. If the allocation scheme also excludes use of adjacent channels and image channels, more than half of the spectrum is unavailable for use.

With higher-performance television tuners, those that offer the higher selectivity needed to reject the taboo channels, the spectrum could be more efficiently utilized. This would lead to a richer set of broadcast media and/or a reclamation of spectrum for other uses.

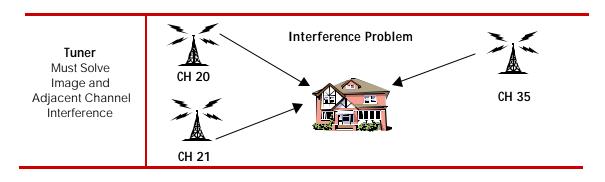
Recently, the new DTV broadcasters have been granted licenses to broadcast in the taboo channels. The chart below depicts the Los Angeles spectrum once DTV signals are added.

AFTER DTV: UHF NTSC AND DTV SPECTRUM FOR LOS ANGELES



DTV broadcasts within the NTSC spectrum are being permitted under the assumption that digital signals will not cause interference problems for existing analog channels. This view is based on the nature of a digital signal. A digital signal does not possess a strong picture carrier and it distributes its signal energy evenly across the channel. It is believed that these characteristics will prevent interference. Many experts are doubtful of this. In fact, broadcasters, the FCC and TV manufacturers are beginning to realize that advances in tuner technology are required to prevent interference in the reception of both analog and digital signals.

THE INTERFERENCE PROBLEM



SPECTRUM EFFICIENCY AND DEMODULATION

Spectrum efficiency also impacts the issues of 8-VSB and COFDM. 8-VSB has more bits per hertz of bandwidth than COFDM, and consequently it uses spectrum more efficiently. According to the Australian DTTB Report, COFDM needs an extra megahertz of bandwidth per channel (7 MHz for COFDM versus 6 MHz for 8-VSB) to get 19.3 Mb/s of data, the amount required for HDTV. The idea behind COFDM is to provide immunity to multipath. It does this by taking a bit stream and breaking it up into several concurrent bit streams. Additional complexity is incurred in the COFDM demodulator by dividing the streams into several isolated (orthogonal) channels. The bits are coded into symbols, and because symbols are now placed in several parallel channels, the symbol rate can be low (1/256us), so low in fact that the time between symbols is very long, relative to the time difference of arrival of the multipaths.

This is not the case for 8-VSB. The symbol rate (1/93ns) is such that typical multipath delays are a meaningful proportion of the period between two symbols, resulting in intersymbol interference. However, 8-VSB is much simpler because it is only one channel.

Proponents of 8-VSB point out that the intersymbol interference issue can be handled by sophisticated equalizers. These equalizers sense the secondary path or paths, invert them and subtract them from the signal, thus removing the offending multipath(s). Some multipaths are harder to remove than others since they are caused by moving objects rather than stationary ones. These objects could be airplanes or, even, people walking around a room. This is the dynamic multipath problem, and requires that the equalizer adapt to changing conditions. In the Sinclair tests, latest and greatest equalizer technology was not used, and as a result, the results are not alarming.

Another important issue is the power level required by each demodulation scheme. The Australian DTTB Report also found that an additional 4 dB of power was required for DVB-T (COFDM) to achieve the same coverage as ATSC (8-VSB). Considering both spectrum efficiency and power, 8-VSB appears to be a good choice, assuming that advanced equalizers will solve the multipath problem.

ROLE OF ADVANCED ICS IN SOLVING THE DTV TECHNICAL PROBLEMS

Engineers, in solving a technical problem, generally follow a simple rule. Determine what is fundamentally important and place the burden for making the solution work on complex digital signal processing algorithms and advanced integrated circuits. In the case of DTV, the fundamental issues are spectrum efficiency and power. There are two critical pieces of technology necessary to make the system work. They are the RF tuner and the 8-VSB demodulator. Much has been written recently about two new demodulator devices, the NxtWave Communications NXT2000 and the Motorola MCT2100, which are good first steps in addressing the vexing static and dynamic multipath problems. I believe that these problems will be solved quickly.

Because of the high industry visibility surrounding the multipath/demodulation problems, little attention has been paid to the performance of the RF tuner and its role in digital TV. The tuner is the critical device in the system that connects to the antenna and the broadcast world. From all of the channels present, whether digital or analog, it must select one and down-convert it to a standard intermediate frequency (IF) and filter out everything else. 'Everything else' consists of other channels and RF interference. The role of the demodulator is to take the standard IF, digitize it, and convert that to a bit stream suitable for an MPEG2/ATSC decoder. The role of the tuner and demodulator in solving the two technical challenges of DTV is presented in the chart below.

Challenge	Multipath Problem	Interference Problem
Problem/Source	Transmitted signals arrive at	Strong analog or DTV broadcast
	receiver from multiple paths	in taboo locations causes
		interference
Consumer Impact	Creates ghosting in analog;	Creates patterned lines in
	Loss of signal in digital	analog; Loss of signal in digital
Solution	Better digital demodulators	Higher-performance tuners
Market Dynamics	First wave of demodulators	Attempts to turbo-charge
	did not solve the problem	existing analog TV tuners
	New players emerging	fall short
	with advanced solutions	Higher performance cable
	Major chip vendors getting	STB tuner not optimized for
	into the game	DTV
		MicroTuner combines best
		of cable and TV tuners at
		low cost

DIGITAL TUNER

The digital tuner will differ from conventional tuners used in analog television sets. It must possess the selectivity to handle a packed spectrum, while not sacrificing performance in other areas. It must address the interference problem, which in the digital era means handling strong image and adjacent channels. Traditional tuners lack this level of performance. The digital tuner must offer improved performance across all parameters, including

Sensitivity (noise figure),

Dynamic Range (the ability to receive strong and weak signals)

Distortion

Phase Noise (important in distinguishing symbols in digital transmissions)

Selectivity (such as image and adjacent channel rejection).

This level of performance can be achieved by making more expensive discrete tuner designs or by taking an entirely different approach. At Microtune[™], the approach was to leverage the advancing state-of-the-art in integrated circuit design to produce a tuner with the performance necessary for digital television, while not injecting extremely high cost burdens on it. Microtune's tuner, the MicroTuner[™], is the industry's only single chip broadband tuner and it is based on patented technology and all-silicon design to achieve new levels of performance, quality, and reliability optimized for digital TV.

CONCLUSION

The key to making the DTV system work at an affordable price is new and improved technology. The source of this technology is the inexorable advance of integrated circuit technology. It can be expected to bring the cost in-line for the high-end signal processing required to overcome the prickly current technical issues. It always has, and soon, we will be able to enjoy the best digital broadcasting system in the world.

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